REMARKS

In order to correct a recurring typographical error, "flit" has been replaced with "frit" throughout the specification.

Review and reconsideration on the merits are requested.

Claims 9-13 and 18 were rejected under 35 U.S.C. §112, second paragraph. The Examiner considered claims 9-13 to be indefinite as failing to specify the dimensional characteristic of the claimed "inorganic matter" having a size of 10 μm or less. The Examiner considered claim 18 to be indefinite as failing to further limit its base claim.

Applicants respond as follows.

The specification at pages 22-23 describes that the inorganic matter results from the aggregation of ceramic particles previously contained in the copper paste, or inorganic components contained in the ceramic green sheet, and which have diffused into the via conductor. The inorganic matter is present in either of a spherical, nearly spherical or amorphous shape. Because its form is nearly circular in many cases, the long diameter thereof is taken as a size of the inorganic matter. When the cross-section is not circular, the size is given as the equivalent diameter of a circle having the same surface area.

In view of the above, claims 9 and 10 have been amended to recite that the inorganic matter has a size of 10 μm or less, said size being a long diameter thereof where the inorganic matter has a spherical or near spherical shape or an equivalent diameter where the inorganic matter has an amorphous shape.

Claims 4 and 5 have been amended in a like manner.

Claim 18 is independent and does not have a base claim.

It is respectfully submitted that the claims as amended herein fully comply with 35 U.S.C. §112, and withdrawal of the foregoing rejection is respectfully requested.

Characteristic features of the present invention:

A characteristic feature of the present invention lies in incorporating inorganic fine particles in a Cu paste, the inorganic particles having a particle diameter of 100 nm or less. See claims 1, 2, 18, 23, 25 and 26. In the cited prior art, the inorganic particles have a dimension of about 1 μm or larger, thus differing from the present invention in this respect.

A primary object of the present invention is to simultaneously prevent protrusion of the via conductor and migration of glass to the via conductor surface (page 8, lines 17-25 of the specification), and the present inventors found that incorporating inorganic fine particles of a specific size is effective for that task. Glass frit conventionally used for preventing protrusion tended to migrate to the via surface so as to impair adhesion of a plating layer thereto. According to the present invention, glass need not be incorporated into the paste so as to avoid the problem of glass migrating to the via surface. Hence, plating treatment is facilitated (page 9, line 19 - page 10, line 4 of the specification).

The prior art technique of U.S. Patent 5,287,620 to Suzuki et al, addressed in further detail below, discloses that the respective shrinking characteristics of a green sheet and via powder may be matched by adding an inorganic powder. That is, the object of Suzuki et al is to inhibit the formation of cracks and pores within the via, different from the present invention which seeks to prevent protrusion of the via conductor. In the present invention, the shrinking

characteristics must be regulated more precisely then in Suzuki et al. More particularly, the present inventors discovered that the object of the present invention cannot be solved by the use of inorganic particles of size larger than 0.1 μm. In this regard, Comparative Example 1-B in Table 1 at page 36 and described at page 39, lines 8-10 of the specification shows that addition of Al_2O_3 particles having a size of 300 nm does not provide the effects of the invention.

With regard to plating property, the exclusion of inorganic matter from paste is certainly advantageous. However, the present inventors have not yet found any method which can prevent protrusion without also resorting to the incorporation of an inorganic ingredient. Because inorganic fine particles for protrusion suppression are added to the paste according to the present invention, the via after firing contains an inorganic matter. However, the inorganic matter of the present invention takes on a finely dispersed structure (Fig. 1 of the specification) different from a glass frit, which becomes fused to give a structure expanding over a wide region (Fig. 2 of the present specification). By making use of the fact that a plating film is formed on a fine inorganic matter surrounded by a metal with comparative ease, the present inventors solved the plating problem.

Rejection of claim 9 over Eguchi et al:

Claim 9 was rejected under 35 U.S.C. §102(b) as being anticipated by U.S. Patent 4,789,411 to Eguchi et al. Eguchi et al was cited as teaching a conductive copper paste for use in filling a via hole comprising a copper powder (i.e., an inorganic material) having a particle diameter of 1 to 30 μm, said to overlap in scope with rejected claim 9.

Applicants respectfully traverse for the following reasons.

Eguchi et al discloses a thermosetting paste used for an organic wiring board, entirely different from the LTCC (low temperature co-fired ceramic) wiring board of the present invention. To clarify this difference, claim 9 has been amended to recite that the wiring board is obtained by filling a copper paste in a via hole formed in a green ceramic sheet and firing to form an insulating layer and a via conductor. Eguchi et al clearly does not disclose the ceramic-based wiring board of amended claim 9, and withdrawal of the foregoing rejection under 35 U.S.C. § 102(b) is respectfully requested.

Rejection of claims 9-13 over Suzuki et al:

Claims 9-13 were rejected under 35 U.S.C. § 102(b) as being anticipated by U.S. Patent 5,287,620 to Suzuki et al. Suzuki et al was cited as teaching a method of producing a circuit board having via contacts by filling the via holes from the surface of the green sheet with a conductive paste comprising copper powder and ceramic powder having a particle size of from 0.1 to 1 μm.

Applicants respectfully traverse for the following reasons.

Suzuki et al's description relates to the particle size prior to firing, and thus differs from present claim 9 which relates to the particle size after firing. Claim 9 has been amended to clarify this difference. Because the particle sizes prior to and after sintering are not the same (discussed in further detail below), the particle size of Suzuki et al does not necessarily overlap in scope with that of present claim 9.

From a different aspect, Suzuki et al's invention relates to a production method characterized in that a powder, not a paste, is filled in a via hole. Although Suzuki et al insists

that a robust via cannot be formed with a paste (col. 3, lines 41-56), the present inventors have provided a robust via using a paste. The amendment to claim 9 further clarifies this difference.

Suzuki et al bridging cols. 10-11 describes that a conductor paste was screen-printed on a green sheet having through-holes filled with the conductor, to form a desired circuit conductor pattern on the green sheet. The Examiner considered the conductive paste to be within the scope of the claimed plating layer of claim 11. However, Applicants respectfully submit that the Examiner mistakes "a conductor paste" for "a plating layer", and request reconsideration on this point.

In view of the above differences, it is respectfully submitted that claims 9-13 are not anticipated by Suzuki et al, and withdrawal of the foregoing rejection under 35 U.S.C. § 102(b) is respectfully requested.

Rejection of claims 9, 10 and 13 over JP '922:

Claims 9, 10 and 13 were rejected under 35 U.S.C. §102(b) as being anticipated by JP 5-81922 (JP '922) to Yoshiyuki. JP '922 was cited as teaching a copper conductor paste for filling a via hole comprising copper powder, a refractory filler having a particle size of 0.2 - 5.0 μm and an organic binder.

Applicants respectfully traverse for the following reasons.

Similar to Suzuki et al, JP '922 describes the particle size prior to firing, and thus differs from claim 9 which defines the particle size after firing. Additionally, the paste of JP '922 permits the addition of glass powder, such that the inventors of JP '922 did not recognize the importance of specifying the size of the inorganic matter in the via conductor. To the contrary,

the present invention contemplates that glass frit preferably is not added to secure a good plating property. See new claim 22.

Moreover, although at first glance JP '922 would seem to relate to a via paste for LTCC use, careful examination of its content reveals that JP '922 actually relates to a via paste for secondary metallizing which is filled in a via hole provided in an alumina substrate after firing and then subjected to firing once again. The requirements of a via paste for secondary metallizing are the suppression of snapping or depression, whereby the paste shrinks upon firing yet the substrate does not. JP '922 solves this problem by adding a refractory filler to suppress shrinkage of the paste upon firing. The wiring board of JP '922 has a very porous via structure resulting from imperfect sintering of the via conductor, and thus differs from the structure of the present invention.

Claim 9 has been amended to define the above-noted differences between the wiring board of the present invention and that of JP '922, and withdrawal of the foregoing rejection under 35 U.S.C. § 102(b) is respectfully requested.

Rejection of claims 15-17 and 19 over Suzuki et al:

Claims 15-17 and 19 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Suzuki et al. The Examiner considered that the claimed proportion of the sectional area having a particle size of 2 μm or 5 μm or more and claimed viscosity of 5,000 to 1,000,000 poises are result-effective variables, and that it would have been obvious to set the particle size of the ceramic and the viscosity of the copper powder in Suzuki et al in order to achieve the desired filling density of the via holes.

Applicants respectfully traverse for the following reasons.

The present invention differs from Suzuki et al in the addition of a finely divided inorganic matter for the purpose of protrusion inhibition and the addition of Fe_2O_3 so as to secure air tightness. As discussed above, the invention of Suzuki et al can neither suppress protrusion nor secure air tightness. Therefore, it is respectfully submitted that new claim 25 (corresponds to canceled claim 19), which requires both a ceramic particle having an average particle size of 100 nm or less and an Fe_2O_3 particle, is patentable over Suzuki et al.

With respect to claims 15-17, it is first noted that these claims define the via structure after firing as in claim 9, not the condition of the powder filling prior to firing. See pages 22-23 of the specification. Claims 15-17 have been amended, similar to claim 9, to reflect this difference.

In order to achieve an excellent plating property, the inorganic matter is finally divided to provide the structure as shown in Fig. 1 of the specification, not one where the inorganic matter is fused over a larger region as shown in Fig. 2. The language of claims 15 to 17 reflects this difference in structure in terms of "sectional area percentage". For example, claim 15 defines a via structure in which the inorganic matter having a particle size of 2 μm or larger is present only in 10% or less of the sectional area of the via conductor. That is, the rejected claims exclude those structures in which constituent glass frit is fused to give a structure expanding over a broad region as shown in Fig. 2 of the specification.

Suzuki et al is entirely silent as to the relationship between the via structure after firing and its plating property. Furthermore, Suzuki et al does not recognize or otherwise disclose that

the size of the inorganic particles prior to firing is different from that of the inorganic matter after firing. This is shown in the present specification by reference to Experimental Example 1-E as described bridging pages 47-48 of the specification. Namely, although the inorganic fine particles (average particle size = 12 nm, see Table 1 at page 36 of the specification) did not include a coarse component of 2 μm or larger in size prior to firing, the inorganic matter after firing contained particles having a size of 2 μm or more in an amount of 1.9%. Moreover, the present invention enhances plating property by specifying the coarseness of the inorganic matter after firing, which aspect of the invention is entirely absent from Suzuki et al.

For the above reasons, it is respectfully submitted that claims 15 to 17 and 19 are patentable over Suzuki et al, and withdrawal of the foregoing rejection under 35 U.S.C. § 103(a) is respectfully requested.

Rejection of claims 1, 2, 4, 5, 8-10, 13, 14 and 18-21 over JP '922:

Claims 1, 2, 4, 5, 8-10, 13, 14 and 18-21 were rejected under 35 U.S.C. §102(b) as being obvious over JP '922. The Examiner again cited JP '922 as teaching a copper conductor paste for use in filling via holes comprising a copper powder and a refractory filler having a particle size of 0.2-5.0 μm and an organic binder within the scope of the rejected claims. The Examiner further considered that the claimed organic vehicle content is a result-effective variable, and that it would have been obvious to optimize the same in order to achieve the desired viscosity.

Applicants respectfully traverse for the following reasons.

Preliminarily, Applicants believe that the Examiner meant to reject the above claims as being obvious under 35 U.S.C. § 103(a), rather than under 35 U.S.C. § 102(b) - lack of novelty.

As discussed above, the particle size of the refractory filler in JP '922 is a particle size before firing. In any event, claims 1, 2, 8, 23, 25 and 26 which require a ceramic particle having an average particle size of 100 nm or less or 50 nm or less clearly distinguishes over the refractory powder of JP '922 at paragraph [0006] having a particle size of 0.2 - 5.0 μm (i.e., 100 nm = 0.1 μm). Further in this regard, as shown above, the present invention employs a finely divided inorganic matter, and conventional techniques such as JP '922 which employed coarse particles greater than 0.1 μm in size, cannot inhibit protrusion.

In yet another aspect, the object of JP '922 is to suppress shrinkage of a secondary metallizing paste, and thus essentially differs from the present invention in object and effect (i.e., simultaneous achievement of protrusion inhibition and desirable plating properties).

In yet another aspect, the present invention incorporates Fe_2O_3 for the purpose of enhancing air tightness. This is entirely different from use of an oxidizing agent for the purpose of binder removal as taught by JP '922. See claims 1, 3, 18, 24, 25 and 27. Claims 3, 24 and 27 specifically require an Fe_2O_3 particle in an amount of from 0.1 to 5.0 parts by mass (support at page 14 of the specification), which serves to further distinguish over JP '922.

Applicants further submit that claims 9, 10 and 13 are patentable over JP '922 for the reasons described above with respect to the rejection of the same claims over JP '922 under 35 U.S.C. § 102(b).

In order to further distinguish the invention of present claim 2 which does not require a Fe_2O_3 particle, claim 2 has been amended to require a ceramic particle having an average particle

size of [100 nm] 50 nm or less (support at page 18), a size considerably lower than the lower limit described in JP '922. See also corresponding claims 23 and 26.

In view of the above, it is respectfully submitted that claims 1, 2, 4, 5, 8-10, 13 and 18-21 are patentable over JP '922, and withdrawal of the foregoing rejection is respectfully requested.

Rejection of claims 6 and 7 over JP '922 in view of Tomiyama et al:

Claims 6 and 7 were rejected under 35 U.S.C. § 103(a) as being unpatentable over JP '922, further in view of U.S. Patent 6,489,014 to Tomiyama et al. Tomiyama et al was cited as teaching a wiring board having conductive layers and plating layers covering the conductive layers. The reason for rejection was that it would have been obvious to mount a semiconductor element on the wiring board of JP '922 with a plating layer on the via conductors as taught by Tomiyama et al, so as to allow for excellent bonding while preventing corrosion of the conductive layer.

Applicants respectfully traverse for the following reasons.

Tomiyama et al discloses a plating layer 4 provided over a conductor layer 3 and glass layer 2. The wiring board of Tomiyama et al is for use in constituting a head substrate and the like of an LED array head (col. 1, lines 6-8), and does not illustrate or otherwise disclose a wiring board having a via hole. Therefore, there is no technical motivation to apply the plating layer of the wiring board of Tomiyama et al (which does not have via holes) to the ceramic multi-layer substrate of JP '922 having via holes.

For the above reasons, it is respectfully submitted that claims 6 and 7 are patentable over the cited prior art, and withdrawal of the foregoing rejection under 35 U.S.C. § 103(a) is respectfully requested.

Rejection of claim 3 over Casey et al:

Claim 3 was rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent 5,336,444 to Casey et al. Casey et al was cited as teaching a copper paste composition for use in filling the vias in a multi-layer ceramic substrate containing copper powder, Fe_2O_3 and an organic medium.

Applicants respectfully traverse for the following reasons.

Casey et al discloses a ceramic via composition, particularly a fritless metallurgical paste, comprising copper and an oxidizable second metal selected from iron, nickel and cobalt (claim 1 of Casey et al). Although Casey et al recognizes that the Fe, when used as the oxidizable metal, is oxidized to either Fe_2O_3 or Fe_3O_4 depending on the sintering temperature (col. 6, lines 25-68), claim 3 differs from Casey et al in that the starting copper paste of the invention contains Fe_2O_3 particle (before sintering) whereas that of Casey et al contains Fe.

By incorporating Fe_2O_3 into the starting copper paste as opposed to Fe as taught by Casey et al, the Fe_2O_3 improves air tightness even if added in a small amount. Because Fe_2O_3 (and Fe) raise the resistance of the via conductor, it is desirable to introduce smaller quantities into the paste. That is, incorporation of Fe_2O_3 improves air tightness without substantially raising the resistance of the via conductor, whereas Fe does not. Further in this regard, although Casey et al teaches incorporation of Fe in an amount of at least 5 wt% for securing good airtightness,

sufficient air tightness is achieved in accordance with the present invention even for amounts of 5 wt% or less when Fe_2O_3 is used. Claim 3 has been amended to set forth this difference.

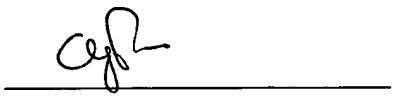
In view of the above, it is respectfully submitted that claim 3 is patentable over Casey et al, and withdrawal of the foregoing rejection under 35 U.S.C. §103(a) is respectfully requested.

Withdrawal of all rejections and allowance of claims 1-18 and 20-27 is earnestly solicited.

In view of the above, reconsideration and allowance of this application are now believed to be in order, and such actions are hereby solicited. If any points remain in issue which the Examiner feels may be best resolved through a personal or telephone interview, the Examiner is kindly requested to contact the undersigned at the telephone number listed below.

The USPTO is directed and authorized to charge all required fees, except for the Issue Fee and the Publication Fee, to Deposit Account No. 19-4880. Please also credit any overpayments to said Deposit Account.

Respectfully submitted,



Abraham J. Rosner
Registration No. 33,276

SUGHRUE MION, PLLC
Telephone: (202) 293-7060
Facsimile: (202) 293-7860

WASHINGTON OFFICE
23373
CUSTOMER NUMBER

Date: May 3, 2004